Fleet Mixture and Arrival Rate Estimation at Memphis International Airport

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Presentation Goals

- Demonstrate applicability of DROMS database at Memphis International Airport (MEM)
- DROMS = Dynamic Runway Occupancy Measurement System
- Estimate parameters for airport arrival capacity modeling at MEM

Objectives

- From January 2003 data (14,252 arrivals) at MEM, estimate:
  - IMC frequency
  - Aircraft weight class percentages
  - Dominant airline fleet compositions
  - Frequencies of aircraft weight class pairs
  - Arrival rates for lead/trail aircraft weight class pairs by regression
  - Effects on capacity modeling

DROMS Database

- Collection at MEM and DTW ongoing:

Airport	Operations	Days
MEM	224,283	215
DTW	518,455	435

- Collection at STL planned in mid-2004
- Planned distribution by Sensis Corporation, NASA, and Volpe Research Center

DROMS Data Sources

- Multilateration position data
  - Cooperative (secondary) surveillance
  - Surface and terminal coverage
    - Surface coverage (MEM, DTW)
    - Terminal coverage (MEM)
- Aviation Situation Display to Industry (ASDI)
- Runway Visual Range (RVR)
- Aviation Routine Meteorological Report (METAR)
- Aviation System Performance Metrics (ASPM)
- Aircraft physical properties
- Aircraft registration data

VMC vs. IMC at MEM

- Analysis of ASPM and flight data:
  - Quarter-hour ASPM data for Jan 2003
  - 73% of meteorological reports are VMC
  - 71% of arrivals landed under VMC
- Conclusion:
  - Arrivals can be segregated by meteorological condition without adding bias to data subsets

MEM Weight Class Mixture

- FAA Wake Vortex Weight Classes
  - ICAO classification also available
- 14,252 arrivals in January 2003:
  - large: 40.9%
  - heavy: 30.8%
  - small: 21.8%
  - B757: 1.4%
  - unknown: 5.1%

Airline Fleet Mixture at MEM

- Dominant airlines: 75%
  - Northwest Airlines and Express Airlines: 97% large
  - Mesaba Airlines: 100% small
  - Federal Express: 99.6% heavy
- Other airlines and GAs: 25%
  - 52% small, 48% large

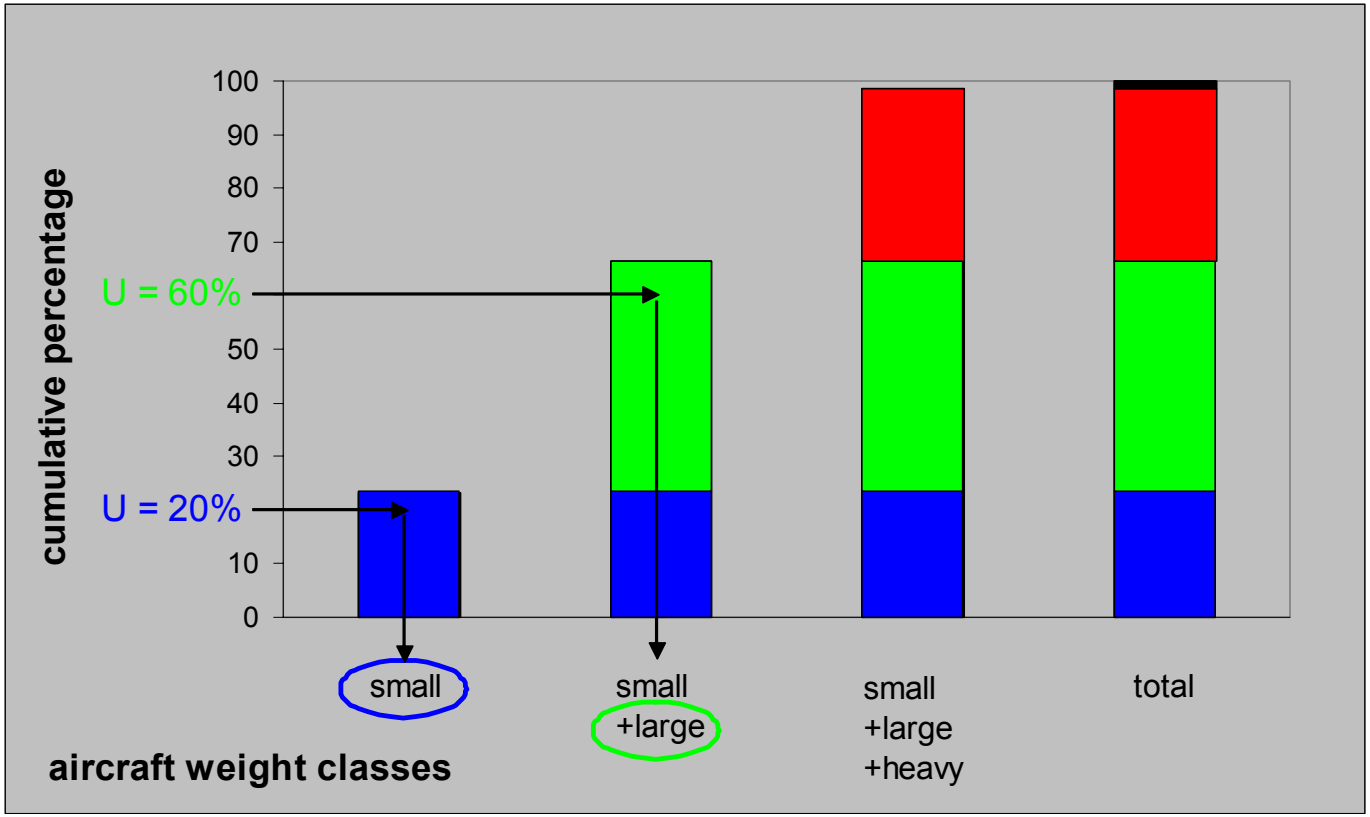
Observed Pair Percentages at MEM

12,844 pairs		Lead Aircraft				
		small	large	heavy	B757	sum
Trail Aircraft	small	6.4	12.9	3.5	0.3	23.1
	large	13.0	25.2	4.5	0.8	43.5
	heavy	3.4	4.7	23.8	0.2	32.0
	B757	0.4	0.8	0.2	0.1	1.5
	sum	23.2	43.5	31.9	1.4	100.0

Independent Pair Simulation

- Simulate expected lead/trail weight class percentages:
  - Lead and trail aircraft weights classes occur independently
  - Lead and trail aircraft weight class pairs are selected from observed weight class percentages (% small aircraft)
  - Averaged over 2.5 x 10^6 Monte Carlo realizations

Weight Class Selection



Independent Pair Percentages (Simulated) at MEM

		Lead Aircraft				
		small	large	heavy	B757	sum
Trail Aircraft	small	5.4	10.1	7.4	0.3	23.1
	large	10.0	18.9	13.9	0.6	43.4
	heavy	7.4	13.9	10.3	0.5	32.0
	B757	0.3	0.6	0.5	<0.1	1.4
	sum	23.1	43.4	32.0	1.4	100.0

Conditional Pair Simulation

- Simulate expected lead/trail weight class percentages:
  - Trail aircraft weight class is conditioned on lead aircraft weight class
  - Markov chain model implemented using observed cumulative weight class pairs

Conditional Pair Percentages (Simulated) at MEM

		Lead Aircraft				
		small	large	heavy	B757	sum
Trail Aircraft	small	6.4	12.9	3.5	0.4	23.1
	large	13.0	25.1	4.5	0.8	43.4
	heavy	3.3	4.7	23.8	0.2	32.0
	B757	0.4	0.8	0.2	0.1	1.5
	sum	23.1	43.4	31.1	1.5	100.0

Independent vs. Conditional Pairs

- Independent vs. observed: σ = 5.28
- Conditional vs. observed: σ = 0.03
- Simulation of single runway capacity (after Lang et al., 2003)
  - Independent: 25.8 arrivals per hour
  - Conditional: 26.5 arrivals per hour

Arrival Rate Regression Models

- Measure quarter-hourly arrival rate
- Measure inter-arrival distance and time spacings between aircraft pairs (grouped by runway)
- Separate by VMC and IMC
- Regress arrival rate on distance and time spacing for lead/trail weight class pairs
- $\log(\text{arr rate}) = b_0 + b_1 \log(\text{spacing})$

Regression Results:

- Arrival Rate vs. Distance Spacing
  - VMC: all but B757 pairs, heavy/small
  - IMC: 5 pair combinations
- Arrival Rate vs. Time Spacing
  - VMC: all but B757 pairs
  - IMC: 6 pair combinations
- Estimate arrival rates from inter-arrival distance or time by weight class pairs

Application of Regression Models

- FAA distance spacing table
- VMC regression equations to predict arrival rate by weight class pair
- Weight class pair percentages:
  - Independent simulations
  - Conditional simulations
- Arrival Rate Estimates:
  - Independent: 36.3 per hour
  - Conditional: 37.0 per hour

Summary, 1

- 14,252 Arrivals to MEM, Jan. 2003
- Estimated VMC vs. IMC frequency
- Fleet mixtures of dominant airlines

Summary, 2

- Weight class percentages:
  - Observed
  - Independent pairing model
  - Conditional pairing model
- Regression models to estimate arrival rates for weight class pair:
  - inter-arrival distance spacing data
  - inter-arrival time spacing data

Future Research

- Extend analysis to include more time data
- Extend analysis to include other airports (DTW, STL)
- Restrict analysis to time periods with high arrival rates
- Identify and estimate statistics of inter-arrival distance and time spacing distributions
- Further evaluate impact on capacity modeling with distance and time spacings based on statistical distributions